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Termite response to Agricultural fiber composites: Hemp

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Termite Response to Agricultural Fiber Composites: Hemp

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Abstract

Industrial hemp, *Cannabis sativa*, is a fiber usable in manufacture of nutritional products, rope, textiles, paper, and building products. Due to the illicit recreational uses of *Cannabis sativa* varieties with a high tetrahydrocannabinol content (marijuana), hemp is not grown commercially in the United States. However, it is grown in many other nations, and has been proposed as a replacement for sugarcane and other commodity crops in the United States, including Hawaii. These studies were undertaken to determine the susceptibility of several potential hemp building products to Formosan subterranean termite attack. Although advocates of the fiber sometimes comment on its relative resistance to insects and decay fungi, there is little to no data available to either substantiate or refute these claims. Termite responses to experimental hemp fiberboards (UF or MDI resins), and to a commercial mineralized hemp building material (Isochanvre) were evaluated in laboratory assays. The hemp fiberboards were readily attacked by termites, although the UF resin was relatively toxic to them in comparison to MDI. Termites also readily consumed the mineralized hemp fibers, although mortality was high. Thus, one can conclude that hemp is susceptible to termite attack. Urea formaldehyde resin in fiberboards and silica, lime or boric acid in mineralized hemp were detrimental to termite survival, but still did not prevent significant attack. Preservative or other treatments appear to be required to protect hemp building products from degradation.

Key Words: *Coptotermes formosanus*, Formosan subterranean termite, *Cannabis sativa*, fiberboard, mineralized hemp

Introduction

Industrial hemp, *Cannabis sativa*, is an agricultural fiber used in the manufacture of nutritional products, rope, textiles, paper, some fiber-plastic composites, and to a very limited extent in building materials. Due to the psycho-active properties of the tetrahydrocannabinol found in high concentration in other varieties of *C. sativa* (marijuana), hemp is not grown commercially in the United States, although it is commonly grown in many other nations. Hemp has been proposed as a replacement for declining sugarcane and pineapple plantations in Hawaii (Thielen 1998, State of Hawaii House of Representatives 1999).

Like other agricultural fibers, hemp can be incorporated into composite building materials. At low levels of substitution (20% or less), replacement of wood fiber with agricultural fiber has little effect on board properties (Hague et al. 1998). Depending upon the properties desired, higher levels of substitution, or even 100% agricultural fiber content, are also possible (Hague et al. 1998), although the economics and environmental benefits of growing agricultural crops specifically for this purpose are debatable (Bowyer 1995, Bowyer and Stockmann 2001).

Advocates of increased hemp cultivation and use sometimes refer to it as insect-resistant, although hemp cultivation is certainly not pest free (Nair 1975, McPartland et al. 2000). The present study was conducted to evaluate the termite resistance of hemp-based fiberboard and particleboard, and of a mineralized hemp building product manufactured commercially in France.

Materials and Methods

<u>Hemp composite boards</u>

Experimentally manufactured 100% hemp fiberboard samples, containing either urea formaldehyde (UF) or methyl di-isocyanate (MDI) resins, were provided by Dr. A. James Bolton, Director, The BioComposites Centre, University of Wales, Bangor, United Kingdom. UF and MDI controls were also provided, as was 50/50 hemp / spruce particleboard (UF resin). Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) heartwood was included as a positive (feeding) control.

Test wafers (ca. 2.5 x 2.5 x 1.2 cm) were oven dried (90° C, 24 hours) to obtain dry weights prior to termite exposure. Wafers of similar dimensions (2.5 x 2.5 x 0.6 cm) were cut from Douglas-fir heartwood. As described in AWPA E1-97 (AWPA 2003), both no-choice and two-choice tests were conducted. In the no-choice (or single-choice) test, termites were presented either with a wafer of composite board or a wafer of susceptible Douglas-fir on the surface of 150 g of damp silica sand (moistened with 30 ml distilled water) inside a screw-top jar (8 cm diameter, 10 cm high). Two-choice tests were performed only with the materials manufactured with MDI resin. In these two-choice test, wafers of two different materials were paired within the same test jar. In each test, there were 5 replicates of each treatment.

Formosan subterranean termites, *Coptotermes formosanus* Shiraki, were collected from a field colony located in Waipio, Oahu, Hawaii, immediately before use in the laboratory, using a trapping technique (Tamashiro et al. 1973). 400 termites (360 workers and 40 soldiers, to approximate natural caste proportions) were added to each jar. After adding termites, the jars were placed in an unlighted controlled-temperature cabinet at 28° C for 4 weeks (28 days). Each jar was inspected weekly for evidence of termite activity in the soil and on the test materials. At the conclusion of the 4-week test period, percentage termite mortality was recorded, the wafers were rated visually according to a 0-10 scale (where 10 is sound, 9 is light attack, 7 is moderate attack and penetration, 4 is heavy attack, and 0 is total failure of the wood sample), and the oven-dry weight change was recorded for each wafer.

Mineralized hemp

Samples of a mineralized hemp building product (Isochanvre, Isochanvre SARL or Chènovotte Habitat, France, developed by Madame France Périer) (Danenberg 1997) were provided by Representative Cynthia Thielen, State of Hawaii House of Representatives. This is a dry product, intended to be mixed with aqueous lime to a cement-like consistency and used to pour flooring or walls (tamped into forms in the voids between the wooden framing members) in the same manner as a thick cement or stucco. Isochanvre is prepared in a proprietary process involving mixing the hemp hurds, which are rich in silica (Danenberg 1997), with unknown ingredients to "stabilize" them. These ingredients may include lime and/or borax or boric acid (Danenberg 1997). Some sources refer to the "sap crystalizing" or "petrifying" during this process. The resulting dry product appears much like hard, dusty wood fragments. It may be used dry as insulation, or wet mixed with lime as a building product.

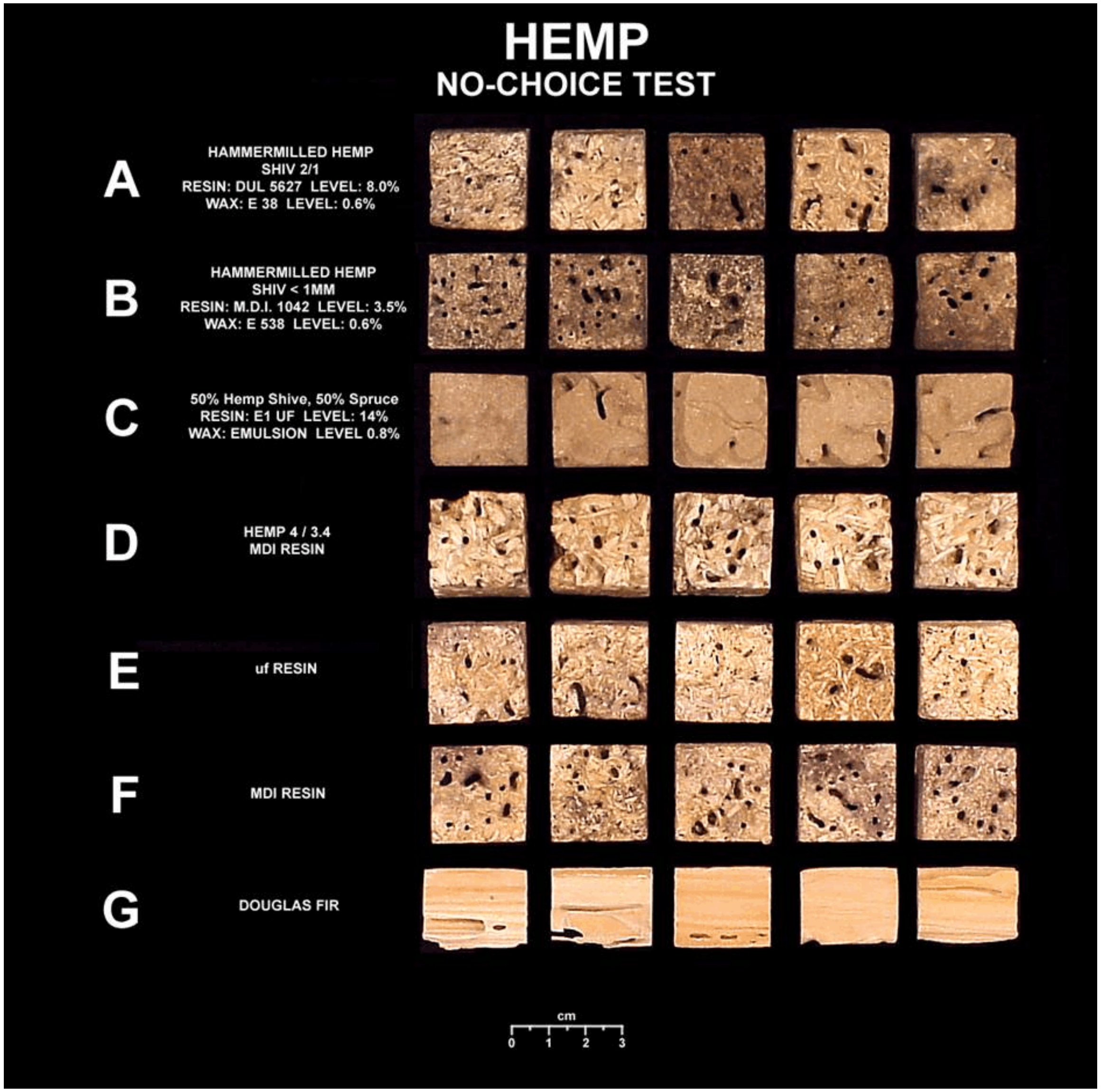
Approximately 2 g samples of the mineralized hemp were oven dried , weighed and placed on the surface of damp sand within test containers in the same manner described above for 4-week, no-choice evaluations (AWPA E1-97, 2003). Douglas-fir wafers (ca. 4 g each) were also included in the test as controls of known susceptibility to termite attack. There were 5 replicates of each of the two treatments (Isochanvre and Douglas-fir). As described above, 400 Formosan subterranean termites were added to each test container, and the containers were incubated at 28° C for 4 weeks (28 days). At the conclusion of the 4-week test period, percentage termite mortality was recorded, and the test materials were oven dried, and mass losses recorded.

Results and Discussion

The hemp boards were quite susceptible to termite attack. In the no-choice tests (FIGURE 1), termite feeding was greatest on the hemp fiberboards with pMDI resin, and exceeded feeding on the MDI wood fiberboard or the Douglas-fir. Less feeding, and much greater termite mortality, occurred with exposure to boards containing UF resin.

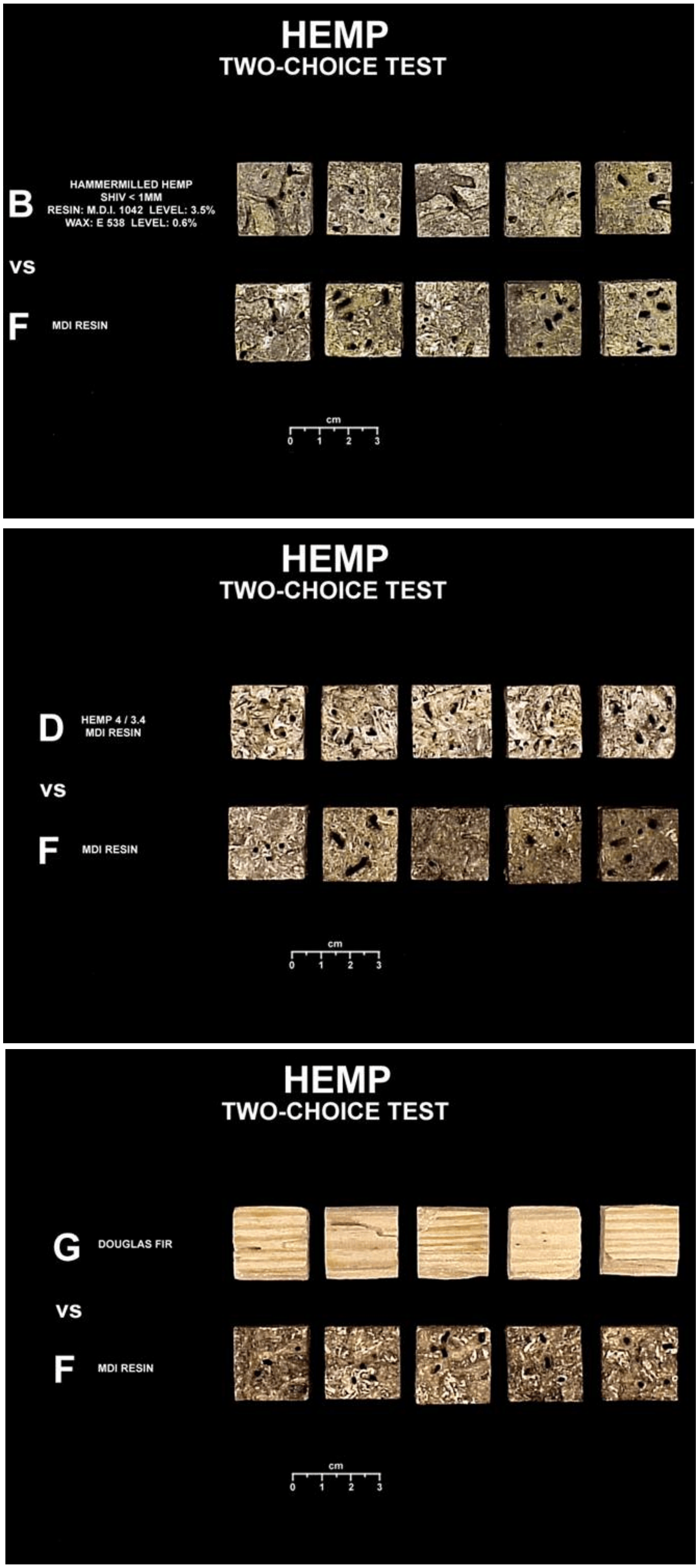
In the two-choice tests with MDI boards (FIGURE 2), equal to greater feeding occurred on the hemp boards in comparison to wood fiberboard.

Significant termite feeding was also observed on the mineralized hemp (TABLE 1), although by the conclusion of the 4-week exposure, this feeding had resulted in ten-fold greater termite mortality (91%) than with the Douglas-fir controls (9% mortality). This may be attributable to the presence of silica in the hemp hurds (G. Leson, personal communication), or to the addition of lime or borax and boric acid (Danenberg 1997) in the mineralization process. Certainly, low borate levels in the product could account for termite feeding followed by high mortality. Under the damp conditions of this test, fungal mycelia were also observed on the mineralized hemp.



Mean Visual Rating	**Mean mg Mass Loss (SD)**	**Mean % Termite Mortality (SD)**
5	**856 (95)**	**98 (5)**
1	**1466 (128)**	**53 (19)**
5	**792 (159)**	**61 (24)**
1	**1084 (195)**	**27 (7)**
5	**744 (197)**	**87 (21)**
2	**953 (141)**	**35 (4)**
0	**938 (113)**	**21 (6)**

FIGURE 1. Hemp fiberboard (A - UF resin; B, D - MDI resin), 50/50 hemp/spruce particleboard (UF resin), and Douglas-fir wafers after exposure to Formosan subterranean termites for four weeks. Wood fiberboards (E - UF; F- MDI) and Douglas-fir (G) included as controls. Mean mass loss (mg) and % termite mortality (with Standard Deviations) are tabulated to the right of the figure.



Mean Visual Rating	**Mean mg Mass Loss (SD)**
5	**817 (168)**
5	**640 (100)**
4	**506 (40)**
6	**441 (123)**
5	**860 (106)**
2	**576 (181)**

FIGURE 2. Termite feeding on MDI hemp fiberboards versus MDI controls in two-choice tests.

TABLE 1. Results of a 4-week, no-choice laboratory test exposing mineralized hemp or Douglas-fir to Formosan subterranean termites.

Treatment	Mean mg Mass Loss (SD)[a]	Mean % Termite Mortality (SD)
Mineralized hemp	1130.94 (103.81)	90.55 (8.54)
Douglas-fir wood	1369.88 (120.41)	9.35 (1.18)

[a] Mass losses adjusted by mean mass change of control samples not exposed to termites: Mineralized hemp - gained 142.40 mg, Douglas-fir wafers - lost 15.60 mg.

The high termite mortality observed in our tests with mineralized hemp suggests that greater insect resistance might occur under field conditions than was apparent under this no-choice situation in the laboratory. In the field, termites have multiple food items available to them, and will avoid foraging areas where high mortality has occurred and dead termites have accumulated. Given the large quantities of mineralized hemp present in structures built with this material (Building Research Establishment 2002), termite damage prior to such an avoidance response might be insufficient to cause structural failure. It should be emphasized that this is speculation, however, and that under the present test conditions termites fed readily on the mineralized hemp when given no other options.

Agricultural fibers do not appear to offer any performance benefits over wood fiber, but certainly may be used in panel manufacture (Bowyer and Stockmann 2001), and may add value due to their uniqueness or perceived environmental benefits (Hague et al. 1998). Despite the hopes of some proponents of increased hemp cultivation, hemp board products, like other agricultural fibers (Grace 1996, 2005), will clearly require protection via incorporation of a preservative or application of an insect-resistant coating when intended for use under conditions subject to termite attack

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